R E M A R K S

The last Office Action has been carefully considered.

It is noted that claims 19 - 21 are rejected under 35 U.S.C. 102 or 103 over the patent to Albert.

Claims 22, 23 and 25 are rejected under 35 U.S.C. 103 over the patent to Albert in view of the patent to Millenaar.

Claims 20, 21 and 26 - 28 are rejected under 35 U.S.C. 112, second paragraph and the specification is objected to.

It is believed to be advisable before the analysis of the prior art to analyze the formal objections and rejections.

In connection with the Examiner's rejection of the claims based on his objection to the term "lining" in claim 20, the Examiner's objection is respectfully accepted and it is proposed to change the term "lining" to the term --frame -- which more clearly describes the nature of the part

in question. The specification and the claims have been amended correspondingly, and the Examiner is respectfully requested to approve the proposed changes.

Claim 28 has been cancelled and claim 26 has been amended to define the X-ray absorbing material as required by the Examiner. The symbols in claims 24 and 26 objected in the Office Action have been amended as required by the Examiner.

In connection with the Examiner's objection to the specification, in view of the fact that the angles added to page 7 of the specification and to claims 24 and 26 are not supported by a corresponding teaching, applicant has submitted an English language text describing the cited angles as Mattsson angles. The specification has been also amended to define that the radiation absorbing layer is one-piece. It is therefore believed that the Examiner's grounds for the objection to the specification and rejection of claims 20, 21 and 26 - 28 under 35 U.S.C. 112 first paragraph should be considered as no longer tenable and should be withdrawn.

Coming now to the Examiner's rejection of the claims over the art, particularly under 35 U.S.C. 102 and 103 over the patent to Albert, applicant wishes to make the following remarks:

Claim 19 has been amended so as to more clearly distinguish the present invention from the references applied by the Examiner. Claim 19 defines in a cellular X-ray grid which has a main body ~~composed of an X-ray transmitting material and~~ I.T. 9/29/94 having a plurality of throughgoing cells separated by a plurality of partitions, and an X-ray absorbing layer which covers all surfaces of the partitions; the main body is composed of photosensitive glass. As will be explained hereinbelow, when the main body is composed of photosensitive glass, the X-ray grid can be formed as a monolithic perforated structure or monolithic cellular grid.

Turning now to the references and in particular to the patent to Albert applied by the Examiner, it can be seen that the Albert grid is not a monolithic structure but instead a multi-layer structure. It is not composed of photosensitive glass or any other photosensitive material. Instead it is composed for example, in one alternative, of X-ray absorbing materials such as lead, tin, lead-containing or uranium-containing glass which has etched openings as disclosed in column 7, lines 27 - 60. In accordance with another alternative it can be composed of light metals such as copper or barium-copper with etched openings and subsequently applied X-ray absorbing layer on the surfaces of the etched plate, for example lead layer as disclosed in column 14, lines 18 - 30.

Still another alternative includes the device composed of light metals, or plastics which surface layers of the above mentioned metals and with etched openings, with lead layer covering its surfaces partially as disclosed in column 14, lines 35 - 60. All three alternatives of the device disclosed in the patent to Albert are produced by applying a thin photosensitive layer with a thickness of n/m or in other words photoresist, on the surface of the main material, then exposing the same with light through a mask, then developing an etching through the exposed part of the photoresist so as to produce openings, through which thereafter analogous openings in the main material are made. Since the etching is performed with the same speed in direction of the depth and width, only very thin layers with a thickness of several tenths of micrometers can be treated in this way, since otherwise the partitions will be etched out as well. Thereby the grid disclosed in the patent to Albert is composite and composed of many layers in direction of its height. For example, if it is necessary to produce the grid with a thickness of minimum 2 mm, it will contain several hundredths of micron layers.

In contrast, when the grid is composed of a photosensitive glass as in the applicant's invention, it is made as a monolithic grid. In such a monolithic structure of photosensitive glass etching is performed through the whole

depth of the structure since the irradiated or exposed portions corresponding to the openings are etched without etching of their walls. The monolithic grid produced from the photosensitive glass is characterized by substantially higher manufacturing accuracy which improves the quality of X-ray diagnostics. Its manufacture is a many hundredths times faster than the manufacture of the composite grid. It permits to provide X-ray diagnostics or treatment of substantially irradiation doses for patients and personnel. It should be noted that the cellular grid disclosed in the patent to Albert has not been implemented in practice and exists only in corresponding articles and this patent. The grid disclosed in the reference is not composed of photosensitive glass or any other photosensitive material. This feature, in particular the grid or main portion of the grid composed of photosensitive glass is not disclosed in this reference and cannot be derived from it. In order to arrive at the applicant's invention from this reference the reference has to be fundamentally modified.

In order to arrive at the applicant's invention from the references the references have to be fundamentally modified by introducing into them the new features which were first proposed by the applicant. However, it is well known that in order to arrive at a claimed invention by modifying the references, the cited art must itself contain a suggestion for

such a modification. This has been consistently upheld by the U.S. Court of Customs and Patent Appeals which, for example, held in its decision In re Randel and Redford, 165 USPQ 586 that:

> "Prior patents are references only for what they clearly disclose or suggest; it is not a proper use of a patent as a reference to modify its structure to one which prior art references do not suggest."

Also, as specified hereinabove, the applicant's invention provided for highly advantageous results which cannot be obtained from the patent to Albert. It is well known that in order to support an obviousness rejection, the art must also suggest that it would accomplish applicant's results. This was stated by the Patent Office Board of Patent Appeals and Interferences in the case Ex parte Tanaka, Marushima and Takahashi, 174 USPQ 38, as follows:

> "Claims are not rejected on the grounds that it would be obvious to one of ordinary skill in the art to rewire prior art devices in order to accomplish applicant's results, since there is no suggestion in the prior art that such a result could be accomplished by so modifying prior art devices."

In view of the above presented remarks and Amendments it is believed that claim 19 should be considered as patentably distinguishing over the art and should be allowed.

It is respectfully submitted that claim 23 should be considered as patentable per se, since neither Albert not Millenar has any hint or suggestion that the cells can be vacuumed.

Reconsideration and allowance of the present application are most respectfully requested.

Should the Examiner require or consider it advisable that the specification, claims and/or drawings be further amended or corrected in formal respects in order to place this case in condition for final allowance, then it is respectfully requested that such amendments or corrections be carried out by Examiner's Amendment, and the case be passed to issue. Alternatively, should the Examiner feel that a personal discussion might be helpful in advancing this case to allowance, he is invited to telephone the undersigned (at 516-243-3818).

Respectfully submitted,

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Agent for Applicant
Reg. No. 28563

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O. Mattsson

Practical Photographic problems in Radiography

B-762/4

THE PROBLEM OF MOTION IN CROSS-GRIDS

Formulation of the problem

In view of all the opinions quoted above I cannot refrain from penetrating to the bottom of the problem. The questions of vital interests are the following:

1. Is it possible, from a mathematical point of view, to obtain films completely without stripes by means of a cross-grid of arbitrary dimensions?
2. If so, in what manner should the grid be moved?
3. What is the effect of the superimposed network of squares on the eye's perception of fine details?

Some introductory photographic tests

To obtain a preliminary idea about the importance of an oblique movement of cross-square systems as a method of compensation for irregular illumination, I have carried out some photographic experiments. These were made with magnified grid models which permitted a very critical evaluation of the results, and by isolating the test from the influence of radiographic technique, screens, and so on, the real effect could be judged more accurately.

By photographic methods a square system was produced which in its dimensions corresponded to a greatly magnified metal grid of conventional type. This system, which was printed on a glass plate and the geometric design of which satisfied high demands of accuracy, was placed in a projector with an anastigmatic lens, well corrected against distortion, and was projected on a surface over which a slide could be moved at certain predetermined angles relative to the orientation of the system of squares. The size of this system when projected corresponded approximately to a linear magnification of 40 times a metal grid. The slide carried a photographic paper which was illuminated by the projected grid while the latter was moving. The speed was maintained at a level which in relation to the size of the squares reduced the risk of stroboscopic effects, a possible complication since the light source of the apparatus was connected to an a. c. supply. However, the light source, an incandescent lamp, supplied a more regular flow of light than a fluorescent tube. A long series of tests were made to find out if, and when,

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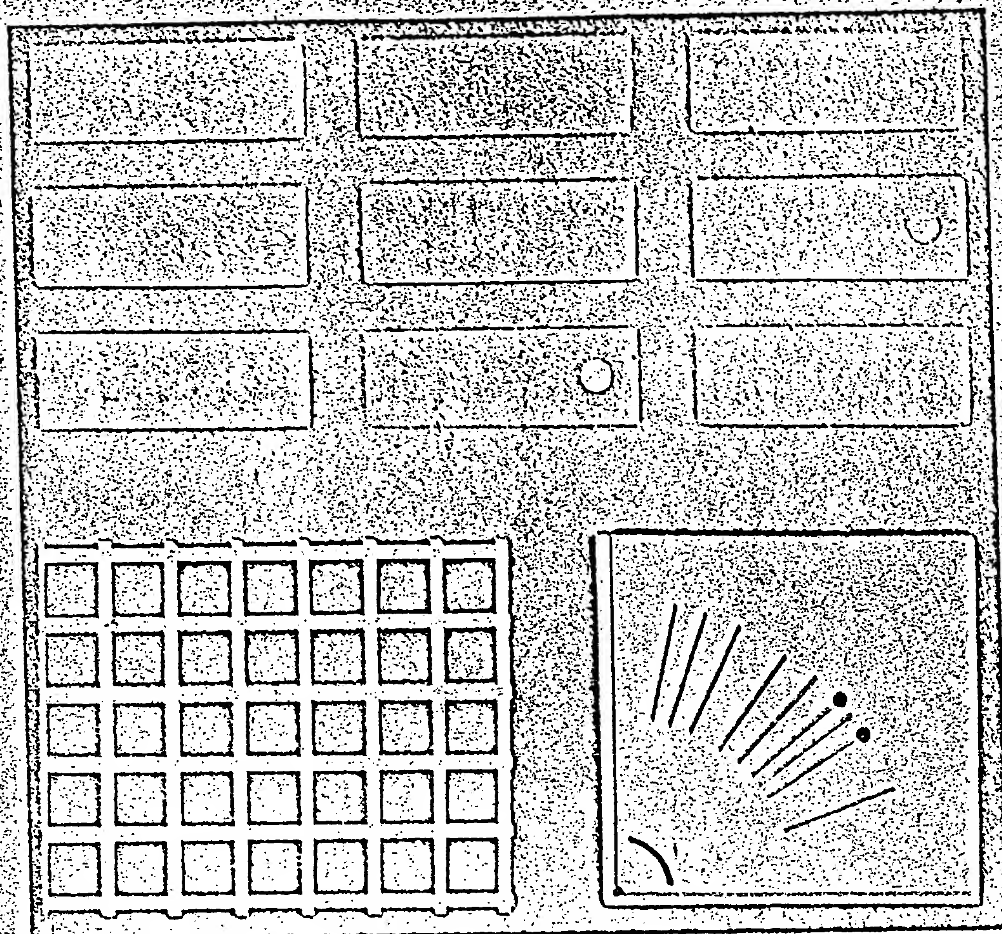

Fig. 34. The effect of varying directions of motion of a grid pattern (bottom left corner). The grey fields above show different degrees of line formation, produced by the movements indicated below. The white and black spots indicate directions where no striping appears.

completely homogeneous illumination could be obtained. A selection of these tests is shown in Fig. 34, which illustrates varying degrees of parallel line formation. Some of these show a strikingly homogeneous illumination. The directions of movement for the tests shown are listed in the lower part of the figure, and favourable directions are marked by black spots; they correspond to the tests showing least structure, which are indicated by white spots. The grid pattern is also shown.

From these tests, which formed the introduction to a more detailed study, it may be concluded that there are good opportunities of re-

ducing the longitudinal lines produced by cross-grids. The fairly common conception that the points of crossing in a cross-grid will always produce lines, independently of the direction of movement, could thus be refuted.

Furthermore, when screens are used and the dimensions of the grid elements amount only to fractions of a millimetre, minor lines will not be visible. With coarser grids and in view of future refinements in the technique it seems, however, to be of the greatest value to make a thorough investigation of the exact optimal angles of motion. It is also necessary to consider the very high degree of resolution obtained by various modern radiographic methods, *e. g.* xerography. It is also true that, however perfectly centered, a grid will be struck by radiation under slightly varying angles during its motion, and that the irradiated surfaces produced by the system of strips of the grid will therefore vary slightly in shape. This contributes to line formation which, however, will be a minimum if the optimal direction of motion has been chosen.

Distribution of illumination — a geometrical analysis

In the following the purely geometric conditions of cross-grid motion will be discussed, and their theoretical background will be studied and clarified.

From the experiments, as well as from some of the comments quoted in the historical review, it appears that it would be possible to suppress very definitely the tendency of visible structure in a radiograph made with a moving cross-grid. It will be shown that there is a theoretical possibility of obtaining an absolute freedom from lines, since it is geometrically possible to achieve homogeneous illumination of the surface situated behind the moving grid. It is assumed that the movement of the grid is of sufficient amplitude relative to the period of time. Purely geometrical relationships must be utilized, and the desired result may be obtained in different ways although always by oblique linear movement. The direction is by no means arbitrary. As will be shown, it is distinctly defined for each type of grid; it varies with the interspace factor, and is primarily connected with the relation between the latter two. Earlier literature, although including patents, reporting that freedom from line formation has been obtained by some kind of oblique movement, gives no information whatsoever about the characteristics of the grid. The interesting laws which reign here — based on simple geometrical principles — have not been discussed previously, which justifies an examination of this problem on the basis of certain experiments, particularly since the problems have come into the foreground lately.

The principles of optimal grid motion are best clarified by certain simple and instructive examples.

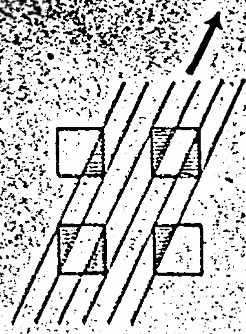

Fig. 39. Interaction of moving squares produces homogeneous illumination. Summation of the shaded corners makes the distribution of light uniform.

The geometrical background of this interaction is easily demonstrated. Fig. 39 shows the general outline of a compensating system of the type now discussed. For a motion producing a homogeneous picture, such as represented by the arrow, the total area of the light-transmitting grid elements passing is constant over the whole of the surface. Summation of the shaded triangles makes the lanes of light pass over into each other without visible borders. The conditions required for homogeneity of the picture may be fulfilled in different ways. Fig. 40 shows one example. The two directions indicated by black arrows may be regarded as reflections of each other; the shaded arrows correspond to the same angles, only with the other grid component as a starting point. As a rule the suitable direction of movement is obtained by connecting two corners of a square with two corners of a square in another row, the respective corners limiting the opposing parallel sides of the respective squares. The angles to be considered are well defined and may be represented by purely mathematical means. The tangent of the angle α in the picture is equal to the relation between the width of the grid strip and the sum of interspace and strip width, and this may be applicable also to other types of grids.

The possibility of compensating interaction with another adjacent row besides the nearest one should also be considered. In that case, the

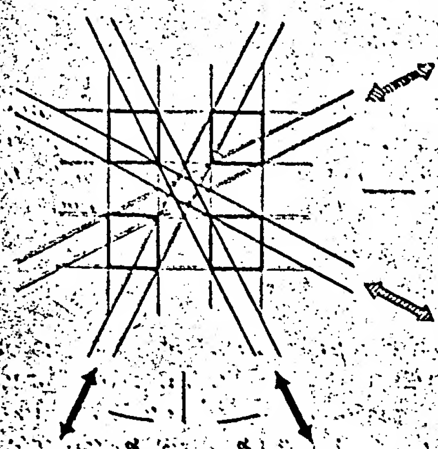

Fig. 40. An example of directions of motion producing uniform illumination; all have the same angular value.

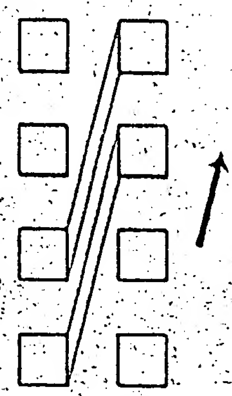

Fig. 41. An illustration of the interaction between different rows of squares not close to each other, for the purpose of homogeneous illumination.

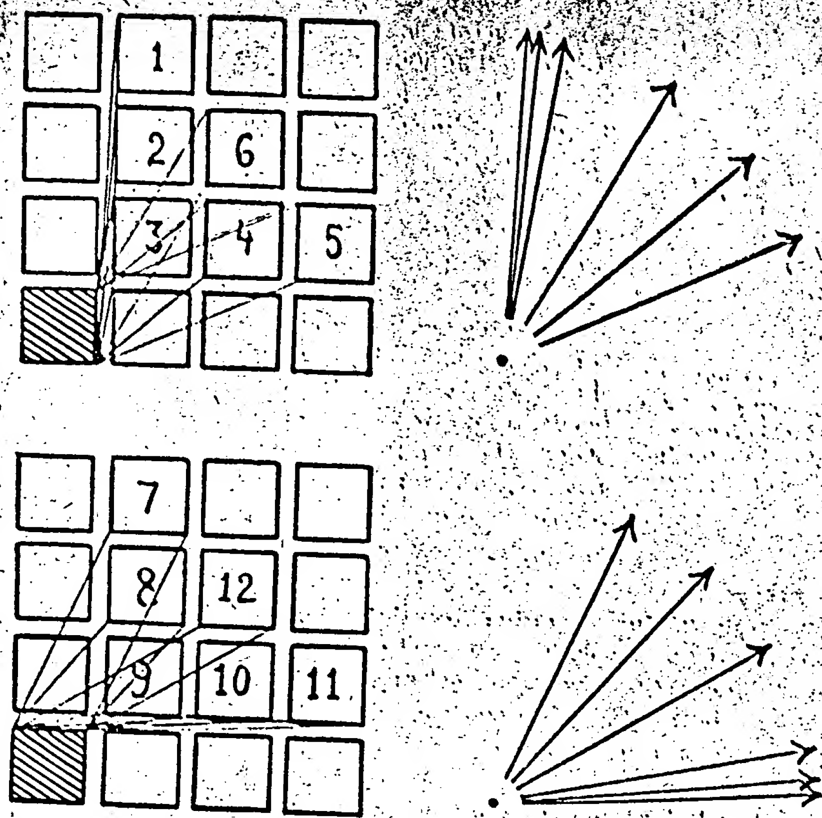

Fig. 42. Possibilities of motion with a grid of ordinary dimensions (interspace factor = 5). The shaded square and the numbered squares will interact. The directions are indicated on the right.

interacting systems will be interwoven with each other in the grid: thus, if the rows of a system are numbered, rows 1 and 3, or 2 and 4, will be interacting. (See Fig. 41.) Longer intervals between the rows may also be considered: in this case new angles of movement will be implied.

Applications to conventional grids

The basic principles outlined above are characteristic of all types of rectangular cross-grids, whatever the relation between interspace and strip width. In the grids commonly used this ratio will be something like 5 to 1, *i. e.* the interspace factor is 5. Fig. 42 shows the geometrical relations of movement with a grid of that kind. The shaded square and the squares with numbers interact. There are no less than twelve possibilities available — the directions are brought together on the right side of the

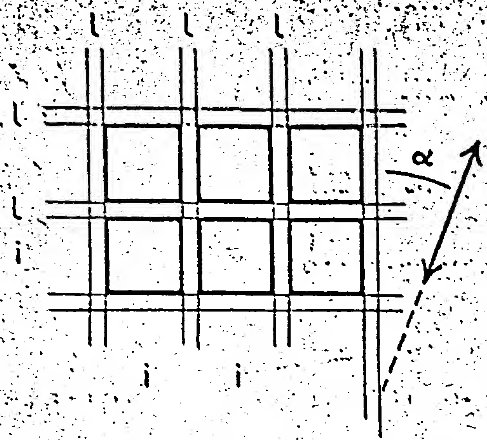

Fig. 43. Illustration of the symbols used in the tabulation below.
(l = lead thickness; i = interspace.)

Tabulation of trigonometrical values of different angles of motion for homogeneous illumination. The symbols are explained in figure 43

$$\mathrm{tg}\ \alpha_1 = \frac{l}{3l+3i} \qquad \mathrm{tg}\ \alpha_7 = \frac{l+i}{3l+2i}\ (=\cot \alpha_5)$$

$$\mathrm{tg}\ \alpha_2 = \frac{l}{2l+2i} \qquad \mathrm{tg}\ \alpha_8 = \frac{l+i}{2l+i}\ (=\cot \alpha_4)$$

$$\mathrm{tg}\ \alpha_3 = \frac{l}{l+i} \qquad \mathrm{tg}\ \alpha_9 = \frac{l+i}{l}\ (=\cot \alpha_3)$$

$$\mathrm{tg}\ \alpha_4 = \frac{2l+i}{l+i} \qquad \mathrm{tg}\ \alpha_{10} = \frac{2l+2i}{l}\ (=\cot \alpha_2)$$

$$\mathrm{tg}\ \alpha_5 = \frac{3l+2i}{l+i} \qquad \mathrm{tg}\ \alpha_{11} = \frac{3l+3i}{l}\ (=\cot \alpha_1)$$

$$\mathrm{tg}\ \alpha_6 = \frac{2l+i}{2l+2i} \qquad \mathrm{tg}\ \alpha_{12} = \frac{2l+2i}{2l+i}\ (=\cot \alpha_6)$$

figure — and more may be thought of. Several of them, however, correspond, i. e. the same angular value is obtained when measuring from the other grid component. This fact is also clearly shown by the tabulation of trigonometric values presented above. The explanation of the symbols is given in Fig. 43 and simple trigonometric laws are applied.

Of the angles theoretically possible some have to be excluded from practical use. There must be an interaction with a relatively close row, otherwise too great a speed and distance of movement will be required of the grid. A compensating action for homogeneous illumination consists in the passage of two units over the film. These must not be too distant

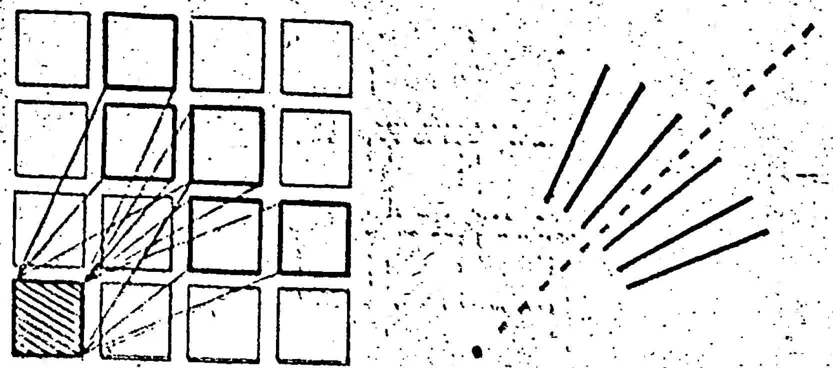

Fig. 44. A selection of six suitable angles of motion and their geo metrical background

from each other. Many such passages will be possible during the exposure, but one of them will perhaps be incomplete. This irregularity in exposure will not be noticeable if it constitutes only a very small part of the total exposure. A similar thing will occur in ordinary single grids. At the beginning of the exposure, some parts of the picture will be shaded by the grid strips and will receive their first illumination later than others. This may be compensated for at the end of the exposure, but often this is not the case. A certain minimum of number of grid units must pass if the summation of exposure impulses is to produce no visible inhomogeneity in the film. The problem was also touched upon by Lotzin (1917) who maintained that at least twelve to fifteen passages are necessary. According to Ledin (1952) the number of illumination changes required is of the order of some 30 for ordinary secondary diaphragms.

Among unsuitable angles of direction may further be mentioned those which approach any of the grid directions. The oblique movement of the grid may be broken up into two component movements, one perpendicular to each grid system. Of course, none of these should be too slow or phenomena of the type just described will appear. The ideal seems to be a direction which gives a sufficiently great component movement for both grid systems. This necessitates a somewhat greater total movement than for a single grid. An additional complication is produced by stroboscopic effects caused by interference by the alternating current impulses which produce an intermittent flow of radiation in the tubes. These effects are more complicated in cross-grids, and will be discussed separately later on.

Fig. 44 shows a selection of six practicable angles of movement and their geometrical background. The angles of movement naturally group themselves uniformly around a diagonal plane of symmetry. Of these six, the middle four will be optimal. (a_4, a_6, a_8 and a_{11}.) They correspond

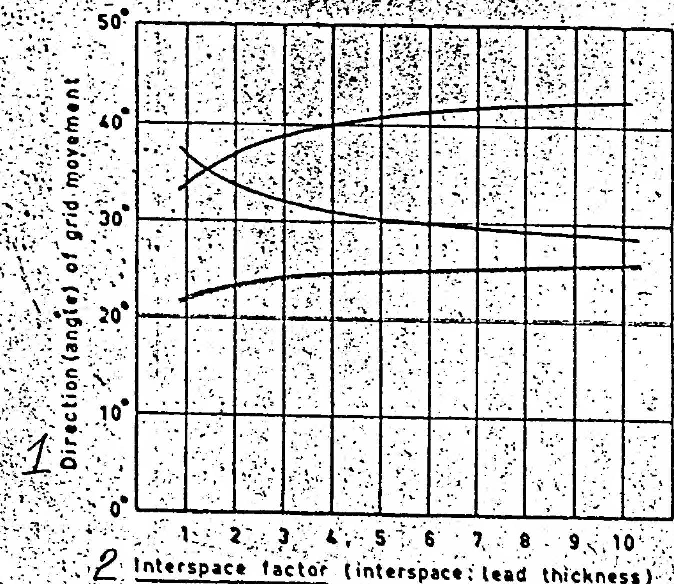

Fig. 45. Angles of motion for obtaining homogeneous illumination for variations in interspace factor between 1 and 10. Refers to rectangular grids with arbitrary dimensions.

to each other two and two as complementary angles, and their tangents and co-tangents agree, as seen from the tabulation below:

Optimal angles of motion for crossed grids. (α_1, α_4, α_8 and α_{12}.)
Symbols explained in Fig. 43

$$\mathrm{tg}\ \alpha_4 = \frac{2\,l + i}{l + i} = \cot \alpha_8$$

$$\mathrm{tg}\ \alpha_8 = \frac{2\,l + i}{2\,l + 2\,i} = \cot \alpha_{12}$$

The great multitude of angles has thus merged into but a few. By using the interspace factor the calculation of the angles will be simplified. The letter symbol l is then changed to the number 1, and the interspace factor is used instead of the symbol i.

Suitable motion of arbitrary grids

Independently of the dimensions of the grid elements, the interspace factor is decisive for the angles of motion. The effective directions of movement for homogeneous illumination for grids of various types are found in Fig. 45. The graph covers variations in the interspace factor lying between 1 and 10 and is applicable for all grids with arbitrary dimen-